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DRIVE RESULTS

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MEMORANDUM

TO: John Struzziery, P.E.

CC: Frank Cavaleri, Aram Varjabedian, Bill Boornazian, Kate Roosa

FROM: Peter Lyons

DATE: December 19, 2017

RE: Town of Hull, MA – Interceptor Hydraulic Model

The purpose of the hydraulic model is to focus on the hydraulic capacity of the Town's most critical collection system asset, the Nantasket Avenue Interceptor (The Interceptor), which is 30-36-inch RCP installed in 1977-1978 and partially rehabilitated in 2006 & 2011. The Interceptor incorporates a 4-barrel inverted siphon (16x10x16x18-inch diameter pipes) at the intersection of Nantasket Avenue and Warren Street as well as a dual pipe (18x24-inch diameter) lagoon crossing located off Fitzpatrick Avenue.

The basis of the hydraulic model is the Town's GIS supplemented with a combination of record drawing review and parcel information. The model was used to perform a high-level assessment of the capacity of the interceptor under average sanitary loading conditions and peak loading conditions. The model is intended to establish baseline sanitary flow and peak flow in the system while locating areas of potential hydraulic deficiencies.

The basis of the wastewater flows in the model are from existing pump station design capacities, MassGIS parcel data, TR-16 peaking factors, and Title 5 design flow schedules. The software used to model the system is Bentley SewerGEMS. Flow meters were not utilized for this high-level assessment, therefore model calibration and model verification were not intended to be completed for this analysis. The model assumes that the interceptor is free of debris and the entire cross-sectional area of the interceptor is available. Figure 1 shows the workflow to create the model.

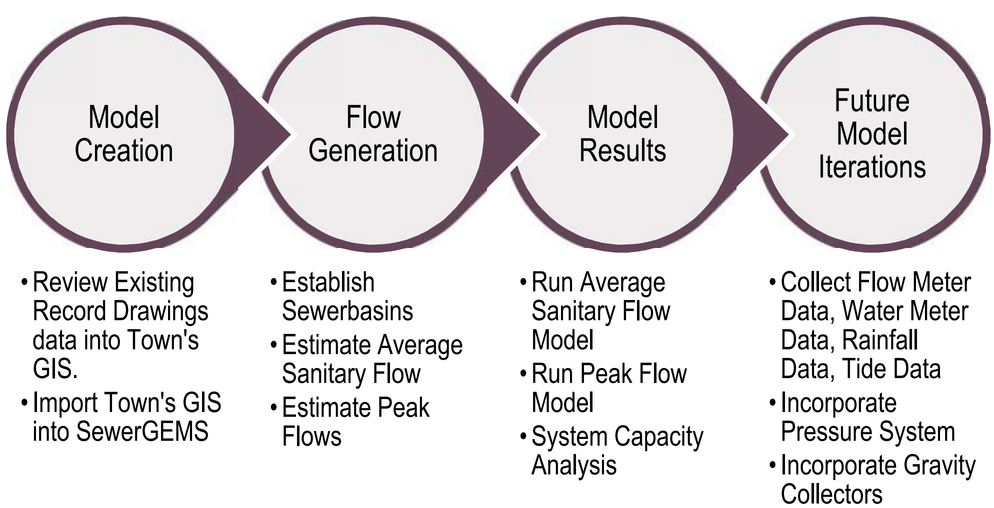


FIGURE 1: HYDRAULIC MODEL BUILDING PROCESS

MODEL CREATION

Utilizing available record drawings (Original Installation – 1970s, Siphon Installation – 1982, Sewer Pipline Renewal – 2010) W&C updated the Towns horizontal and vertical alignment so that pipe lengths, diameters, horizontal layout, invert elevations, and ground elevations could be digitized into SewerGEMS model. This work did not include survey or other methods of field verification. The pipe and manhole elevations included in the model were developed from the 1974 record drawings and thus were converted from NGVD29 to NAVD88. Ground elevations (NAVD 88) were interpolated by the SewerGEMS program using contour data provided by MassGIS. A correction factor of 0.8 was used to correct the NGVD29 elevations to NAVD88 as provided by the Town of Hull Flood Hazard Information website.

NAVD 88 = NGVD 29 - 0.8-feet

After these corrections were incorporated into the Town's GIS, shapefiles were exported into SewerGEMS to create a geometric representation of the Town's Interceptor. Figure 2 shows the Town of Hull collection as represented in the model, note that red is the interceptor and is "active" in the model while the gray lines represent "inactive" pipes that are not included in this analysis.

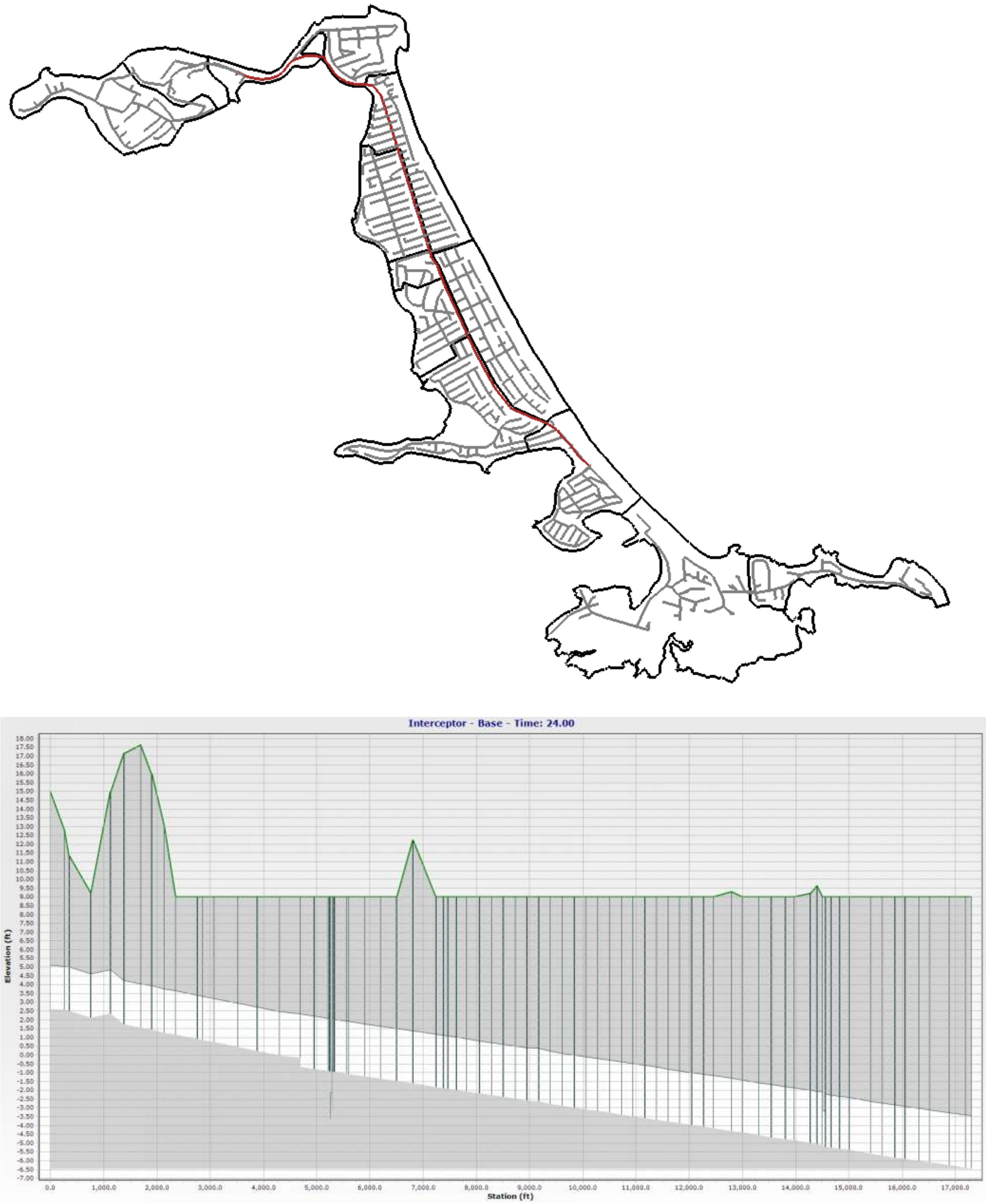


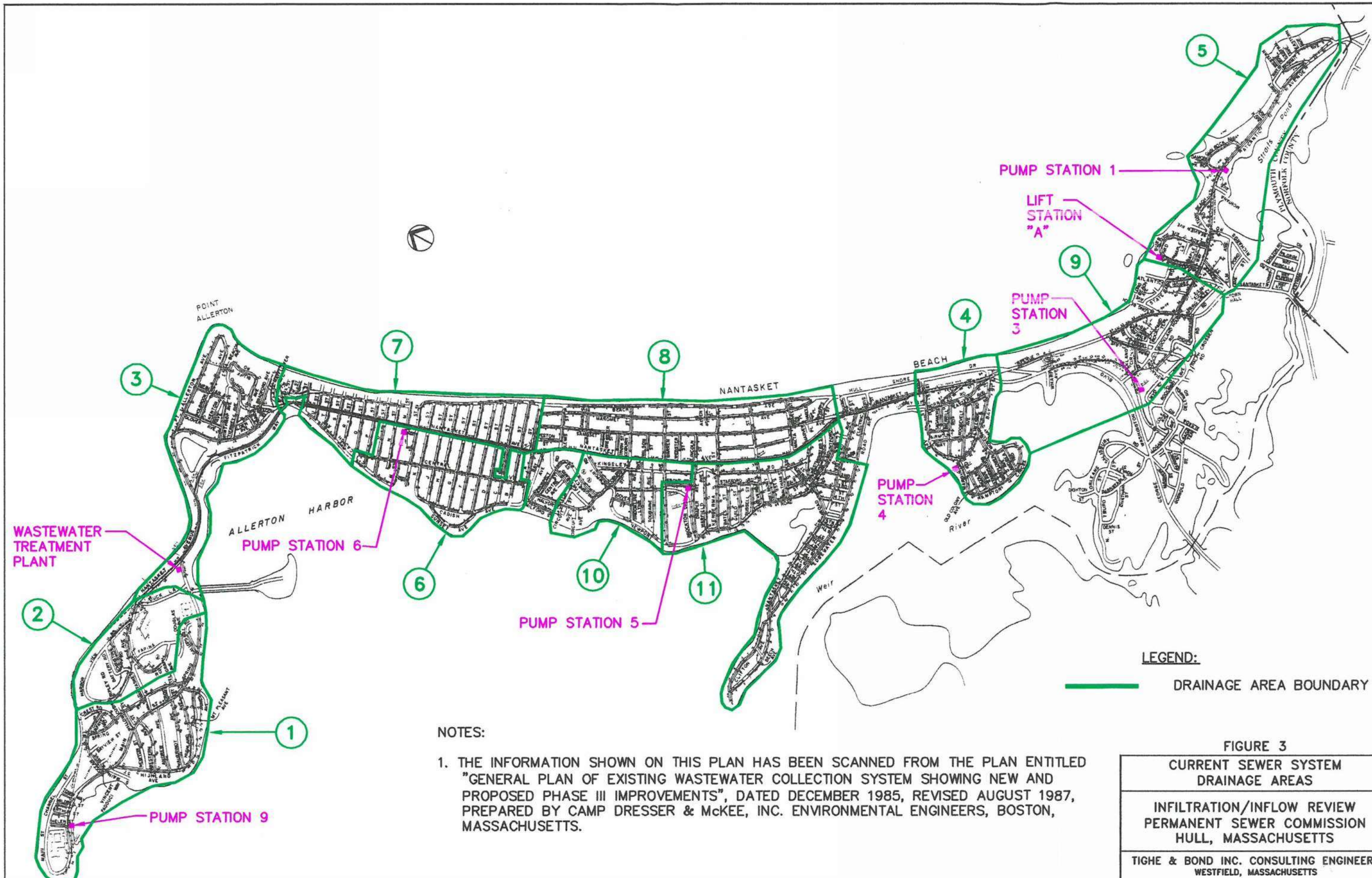
FIGURE 2: OVERVIEW OF SEWERGEMS MODEL AREA (TOP) AND MODEL CROSS-SECTION (BOTTOM)

FLOW GENERATION

Sewer basins were delineated using the delineations created during the *I/I Update Study* (Tighe & Bond, 1999), as shown in Figure 3. Sewer basins are delineated areas of the modeled network that are grouped by their corresponding downstream discharge manhole. For example, all flow from sewershed 4 discharges to the Interceptor at one location. For this analysis, each sewer basin has a single discharge point to the interceptor with a certain diurnal pattern applied to the estimated flow. Pump stations data (pump capacity, wet well size, force main characteristics, etc.) were not modeled, rather pump design discharge flows were as a discharge point to The Interceptor (See Table 1 for the discharge points of each sewershed).

In order to estimate base sanitary loading for each sewer basin a spatial analysis was completed to determine the number of parcels in each basin, the estimated number of bedrooms per parcel, and ultimately the average daily flow from each parcel. 310 CMR 15 was utilized to estimate flow per bedroom for all parcels. Due to a lack of detailed parcel data, at least two bedrooms were estimated for each parcel. For larger parcels with more than 6 rooms, the number of bedrooms was estimated to be the 1 bedroom for every 3 rooms. Each bedroom was correlated to 110 gallons per day of sanitary flow. As a simplification, all parcels were given a residential diurnal pattern – this is a conservative method as peak factors for diurnal flows are generally higher than peak factors for industrial/commercial flows and will also produce peaks at the same times for all parcels. Using this method, a simplified sewershed analysis was performed.

In order to determine peak flows in the system, a “maxing out” approach was utilized. The logic behind this analysis states that the maximum flow in the interceptor will be reached when all pump stations in the Town are at their capacity. Using this method, an approximation of wet weather flows can be reached because during an intense storm event flows to the interceptor will be limited by the capacity of each pump station. For sewersheds that flow directly to the interceptor via gravity, TR-16 peaking factors were utilized to estimate peak flows on a maximum day.



NOTES:

1. THE INFORMATION SHOWN ON THIS PLAN HAS BEEN SCANNED FROM THE PLAN ENTITLED "GENERAL PLAN OF EXISTING WASTEWATER COLLECTION SYSTEM SHOWING NEW AND PROPOSED PHASE III IMPROVEMENTS", DATED DECEMBER 1985, REVISED AUGUST 1987, PREPARED BY CAMP DRESSER & McKEE, INC. ENVIRONMENTAL ENGINEERS, BOSTON, MASSACHUSETTS.

FIGURE 3

CURRENT SEWER SYSTEM DRAINAGE AREAS

INFILTRATION/INFLOW REVIEW
PERMANENT SEWER COMMISSION
HULL, MASSACHUSETTS

TIGHE & BOND INC. CONSULTING ENGINEERS
WESTFIELD, MASSACHUSETTS

SCALE: NONE DATE: FEBRUARY 1999

H0938\HULL4

Estimated Peak Flow Based on Pump Capacity:

The estimated capacity of the WPCF is approximately 8.6 MGD – this is represented in the model by an "outfall" pipe capable of handling 8.4 MGD. When flows to the WPCF reach 8.4 MGD the outfall pipe will begin to surcharge and cause surcharging in the upstream interceptor. Although, the actual hydraulics of the WPCF are more complicated due to storage volumes, pumping capacities, and geometries, this method should provide an adequate approximation of flow limitation induced by the WPCF.

TABLE 1: SEWERSHED FLOW ANALYSIS

Sewershed	Connection to Interceptor	PS Capacity (mgd)	Estimated Average Sanitary Flow (mgd)	Peaking Factor	Estimated Peak Sanitary Flow (mgd)	Peak Flow Based on PS Capacity (mgd)	Discharge MH Model
1	PS 9	0.94	0.12	6	0.74	0.94	20122
10	PS 5	2.30	0.08	6	0.46	via PS8	20580
11	PS 5	2.30	0.18	5	0.89	via PS8	20580
8	PS 5	2.30	0.19	5	0.94	2.30	20580
4	PS 4	1.15	0.15	5	0.74	1.15	20764
5	LSA / PS 1	2.45	0.09	5	0.44	via PS3	20811
9	PS 3	2.45	0.15	5	0.75	2.45	20811
6	PS 6	0.97	0.14	5	0.72	0.96	20332
12	Gravity	-	0.02	6	0.13	0.13	20424
2	Gravity	-	0.02	6	0.14	0.14	20122
3	Gravity	-	0.09	5	0.45	0.45	20131
7	Gravity	-	0.16	5	0.77	0.77	20309

MODEL RESULTS

A high-level capacity assessment was performed for the interceptor that locates hydraulic bottlenecks in the system. Capacity is defined as the ability to convey flow without excessive surcharging or result in an SSO during a given flow scenario. This section assesses the capacity of the Town's hydraulically critical infrastructure – The Interceptor.

Capacity deficiency or performance criteria are used to determine when the capacity of a sewer pipeline is exceeded to the extent that a capacity improvement project (e.g., a relief sewer or larger replacement sewer) is required. Capacity deficiency criteria are sometimes called "trigger" criteria in that they trigger the need for a capacity improvement project. These criteria may differ from "design criteria" that are applied to determine the size of a new facility, which may be more conservative than the performance criteria.

It is important that the capacity deficiency criteria be coordinated with the peak design flow criteria. For example, if the peak design flow considers only peak dry weather flow and little or no I/I, the deficiency criteria should be conservative (e.g., require pipes to flow less than full during dry weather flow to allow capacity for I/I that may increase the flow under a wet weather condition). On the other hand, if the peak design flow includes I/I from a large, relatively infrequent design storm event, it is appropriate to allow the sewers to flow full or even surcharged to some extent, since the peak flows will be infrequent and brief.

The Town should establish hydraulic criteria that aim to eliminate SSOs from occurring during the design storm. Examples of hydraulic criteria the Town should consider are the following:

- Sewer pipes should not surcharge during peak dry weather flow.
- Minimum allowable free-board (depth of maximum sewer level from rim elevation) during peak wet weather flow:
  - Free-board depth > 5-feet

In setting these hydraulic criteria, the key consideration should be the peak design flows based on a peak wet weather flow (PWWF) corresponding to the 5-year, 24-hour (4.12-inches) return period design storm. Given the low frequency and short duration of the peak wet weather flows, a moderate amount of surcharging should be deemed to be acceptable by the Town. Surcharging of sewer pipes during dry weather flow can lead to odors and prevent air flow causing increased maintenance.

While improvements are being made to the rainfall collection and system-wide flow metering, influent flow meters capture 15-minute influent flows at the WPCF using SCADA and Hach® WIMS. Using the wastewater flows measured during the April 1, 2017 Storm (3.84-inches of rainfall, .08-inches/hour peak intensity), a high-level calibration of the model was completed. Figure 4 below shows the models estimated dry weather flow (blue) and peak flows based on pump station capacities and gravity flow peaking factors (orange). The peak weather flows are slightly above the flows that were measured during the April 1, 2017 storm (tan) – which will depict a conservative estimate of the wastewater flows during a large storm event. Note that the modeled average sanitary flows are slightly lower than the measured flows, one potential reasoning for this is because the model does not incorporate infiltration under the average sanitary flow condition.

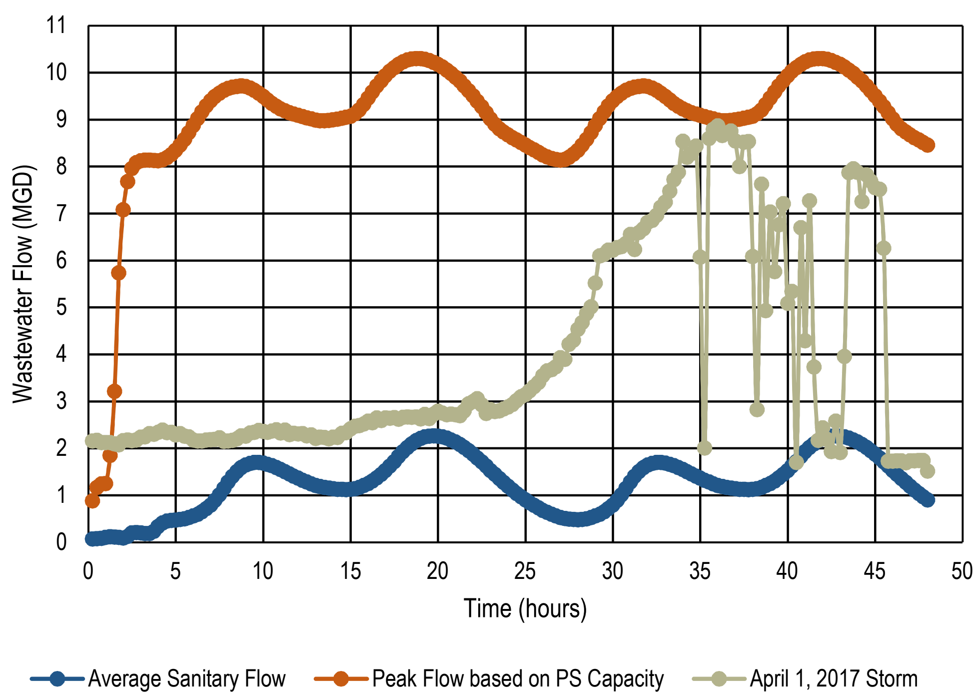


FIGURE 4: MODELED FLOW COMPARED TO RECORDED STORM FLOW AT WPCF INFLUENT METER

Average Sanitary Loading Capacity Assessment

The model estimates average sanitary flow from sewer customers to be approximately 1.38 MGD which is has low flows (near midnight) at 0.3 MGD and peak flows (around dinnertime) at 2.3 MGD. The model does not predict any manholes to have a freeboard depth of less than 5-feet. See Figure 5 for the results as shown in the SewerGEMS model; the blue shading indicates the hydraulic grade line (flow level), and red indicates the energy grade line (areas of intense flow).

Peak Flow Capacity Assessment

The model estimates peak flow due to pump station pumping capacities and estimated peak gravity flows to be approximately 10.3 MGD. The model does not predict any manholes to have a freeboard depth of less than 5-feet. One manhole approaches the 5-foot threshold, MH20774, which is the manhole upstream of the negatively sloped pipe, is the manhole closest to overflow at 5.6-feet. See Figure 6 for the visual SewerGEMS model output.

An additional model was run in order to show the effects of debris on the capacity of the interceptor. The following profile shows the interceptor during peak flow with 6-inches of debris across the length of the system. The effect of debris on the maximum hydraulic grade line during peak flows highlights the importance of a regular cleaning an inspection of the Town's most critical collection system asset. See Figure 7 for the visual model output.

FUTURE MODEL ITERATIONS

1. Collect 15-minute interval wastewater flow data at critical junction manholes to further define wastewater flows in the system for each sewer basin. This data will be used to calibrate the model for dry weather and wet weather flows.
2. Collect elevation data for non-interceptor collection system to understand hydraulic deficiencies in less critical portions of the collection system.
3. Incorporate pump stations (pump data, wet well size, force mains) into the model.

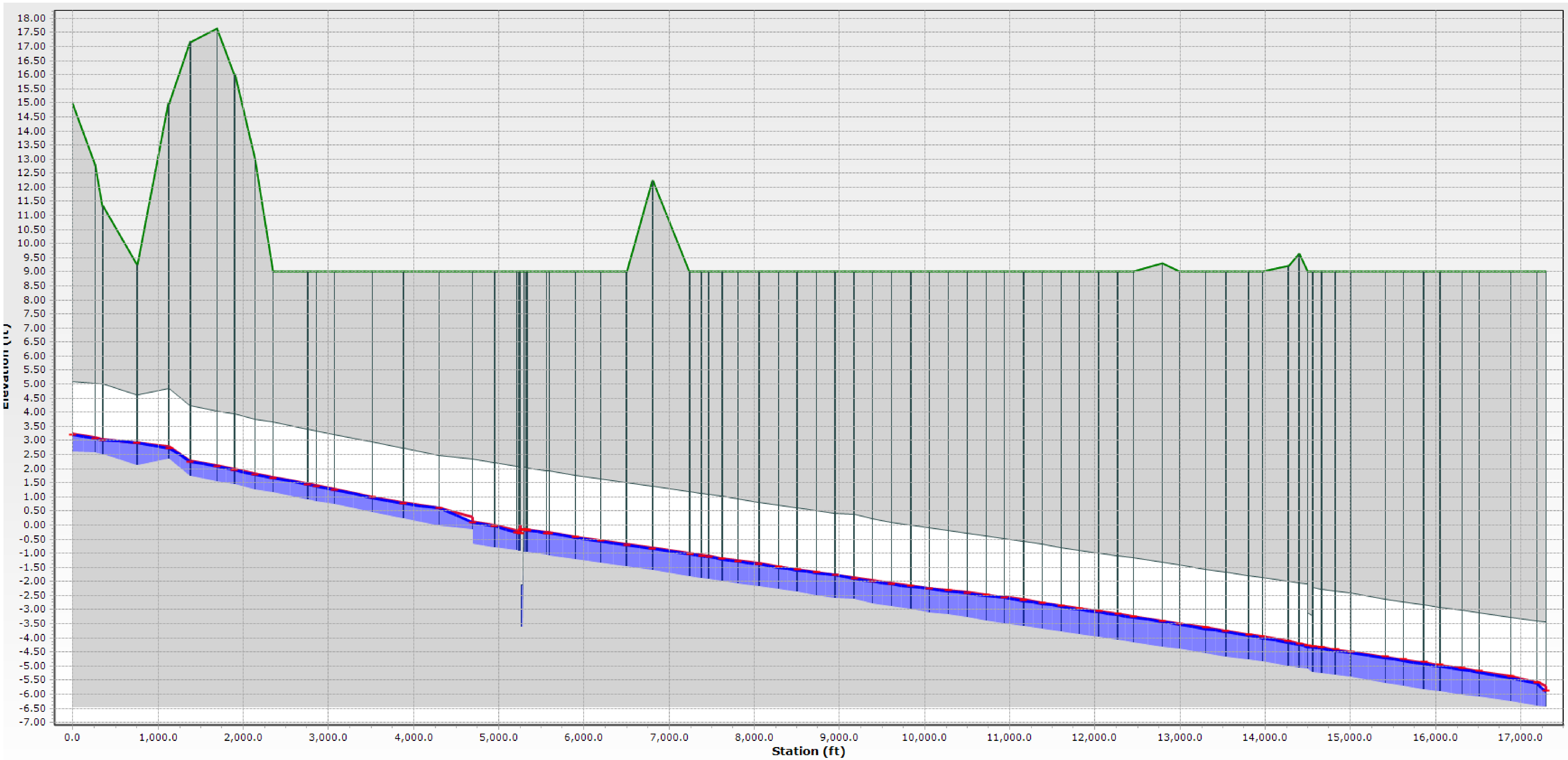


FIGURE 5: AVERAGE FLOW, TIME 18.75H

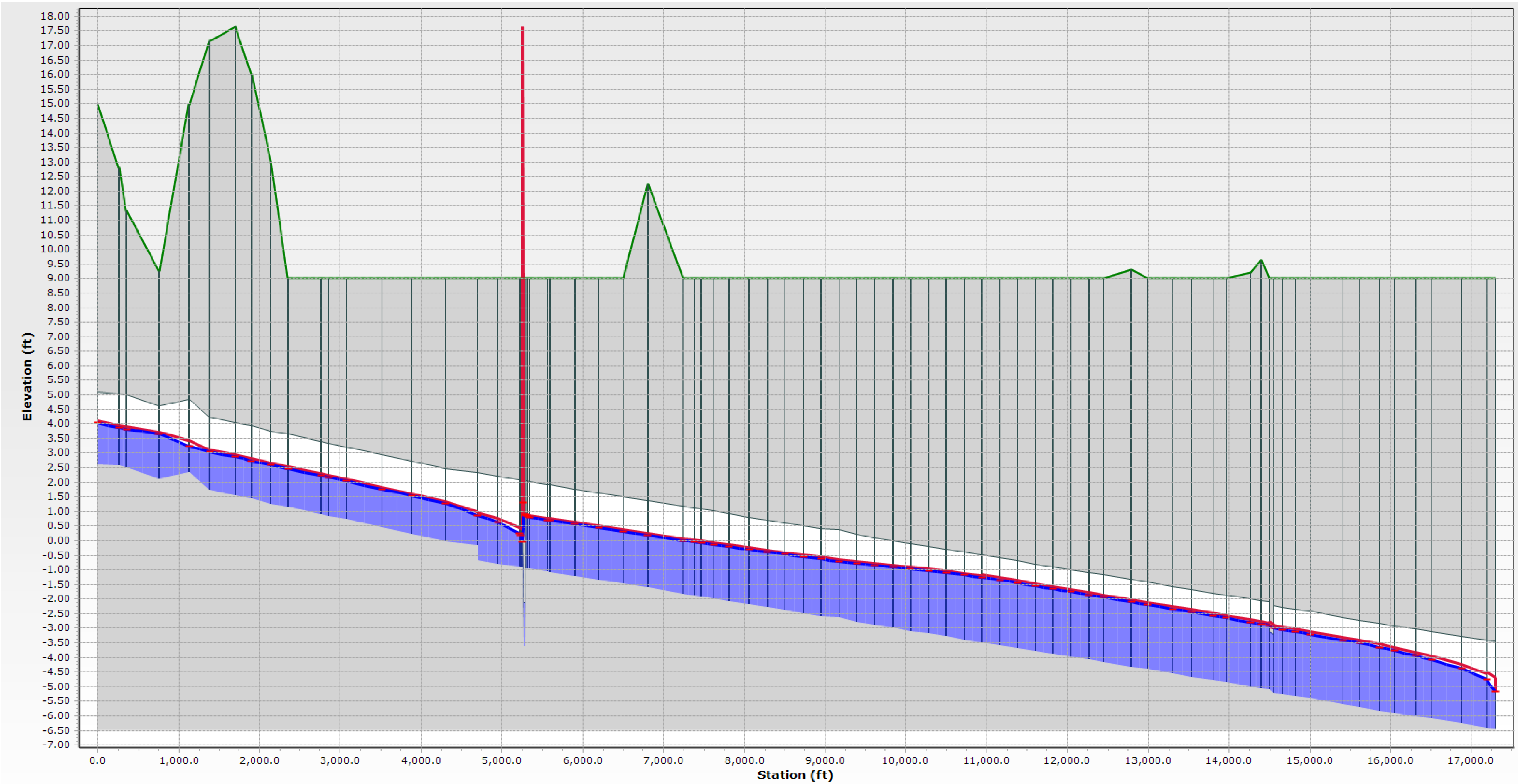


FIGURE 6: PEAK FLOW MODELED WITH PEAKING FACTORS, TIME 18.75H

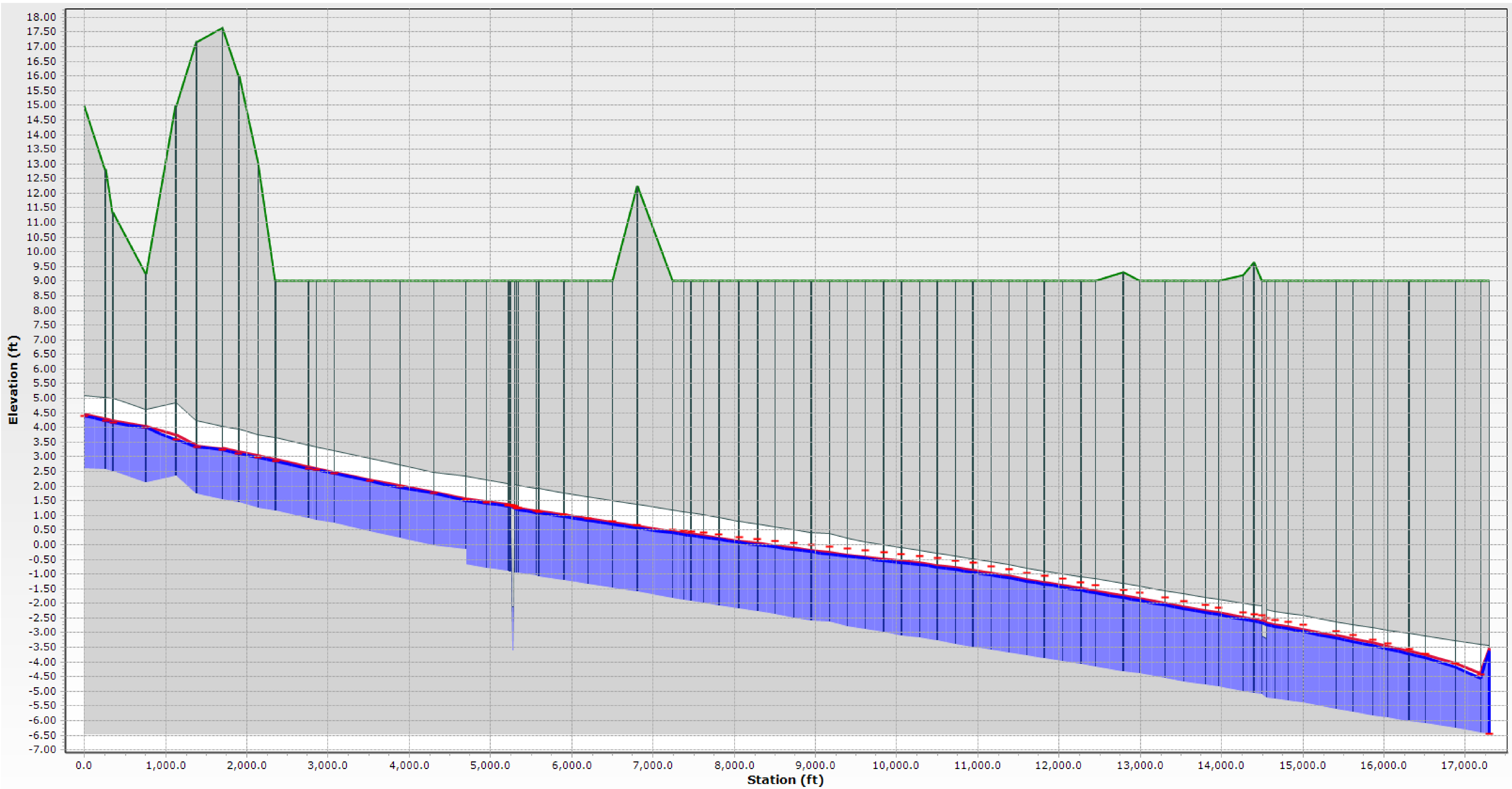


FIGURE 7: INTERCEPTOR PEAK FLOW (GRAVITY AND PUMP STATION) WITH PEAKING FACTORS, TIME 37.5H